Learned Discourses: Timely Scientific Opinions

Assessing Effects of Plant Protection Products on the Breakdown of Organic Matter: Regulatory Requirements, Problems and Prospects

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Introduction

To minimise the environmental risk posed by the use of agricultural chemicals, European Directive 91/414/EEC and its subsequent amendments (Directive 96/12/EC) stipulate that plant protection products should be evaluated for their possible effects on the breakdown of organic matter (OM).

Current opinion, based on recommendations from a working group led by the German Biologische Bundesanstalt (BBA), is that litter-bags should be used as a higher tier test for effects of plant protection products on the mass loss of plant litter (Kula and Guske 2001).

Experience with the litter-bag test is increasing, and draft test protocols have been developed by the BBA. But questions remain. For instance, is the litter-bag test the most appropriate method for assessing effects of plant protection products on OM breakdown? If so, what are appropriate triggers for the test? To support the UK Pesticides Safety Directorate, the Department for Environment, Food and Rural Affairs (DEFRA) recently commissioned a study to determine the state of knowledge on test methods for assessing breakdown of OM and their relevance to the risk assessment of plant protection products, and on the role of soil microorganisms and soil fauna in plant litter decomposition.

Limitations of Current Tests

A test for effects of a pesticide on OM breakdown is required (Directive 96/12/EC, Annex II, Point 10) if:

- the pesticide is persistent, or
- it is harmful to soil microbial processes or earthworms (as determined from lower-tier tests), or
- there is a risk to other soil fauna (as determined from "further" single-species tests).

Earthworm tests are the only tests on soil fauna used routinely in the risk assessment scheme; other tests on Collembola, Enchytraeidae, and Acari have standard methods. However, the relevance of these single-species tests to the functional endpoint is presently unclear and for many other functionally important groups of soil fauna (e.g., Diplopoda, Isopoda, Mollusca, Nematoda, and Protozoa) standard test methods are lacking (van Straalen and van Gestel 1998).

Tests on microorganisms and microbial processes are difficult to relate to OM breakdown for four principal reasons: (1) The degree of functional redundancy among microflora is unknown; (2) Some tests are too general (e.g., soil respiration); (3) Some microbial tests are too specific (e.g., nitrification); (4) The role of individual soil enzymes in decomposition is difficult to quantify.

"Early Warning" (Middle-Tier) Predictors of Risk to Organic Matter Breakdown?

Multiple enzyme activities might have predictive value for risk to OM breakdown if studied simultaneously using the "Biolog" method (Dighton 1997).

- It is not dependent on the identification of particular microbial species.
- It can be automated as a high-throughput screening tool.
- Results can be obtained quickly (in 70 hours).
- The method could be modified for the OM breakdown endpoint.

However, this method also has drawbacks. In particular, it is suitable only for culturable microorganisms (which make up a small proportion of the soil microflora).

An alternative (or additional) approach is the catabolic response profile (CRP) (also known as in-situ catabolic potential; Degens and Harris 1997). This approach directly assesses the catabolic diversity of microbial communities by adding a range of simple organic substrates directly to soil and measuring the short-term catabolic activity as CO_2 output. It is not limited to culturable microorganisms but problems of functional redundancy might occur if substrates are utilised by a wide range of microflora, and clarification is required on which aspects of catabolic diversity are most relevant to OM breakdown.

The Biolog and CRP methods offer flexibility in the choice of substrates that can be used and hence might be developed further as predictors of OM breakdown.

Are Litter-Bags Appropriate for the Functional Endpoint Test ?

Five methods that could have relevance both to the functional process of OM breakdown and to the risk assessment of pesticides are reported in the literature. These are the litter-bag (Kula and Guske 2001), minicontainer (Eisenbeis et al. 1999), cotton-strip assay (Harrison et al. 1988), stable C and N isotopes (Nagel et al. 1995) and bait-lamina assay (von Törne 1990). We compared these methods on the basis of 24 suitability criteria. Only the litter-bag test was found to be sufficiently well developed and relevant to be suitable as a technique for assessing pesticide effects on OM breakdown in the field.

Future Directions

Although the litter-bag test is currently the most appropriate method for assessing effects of pesticides on OM breakdown, several aspects of the methodology still have to be addressed.

- The ecological relevance of the litter mass loss endpoint requires clarification.
- Exposure scenarios need to be determined for different agricultural management conditions, soils and crop types.
- A means of validating litter-bag tests is required (e.g., using appropriate toxic reference substances or chemical fate data).

The methodology has not been sufficiently well developed for application in ecotoxicology yet, but integration of stable isotope methods with the litter-bag test might in future provide enough information on C and N transformations in the field to allow risk to be determined without requiring the full time course of the litter-bag test to be completed.

Perhaps the most difficult task for optimising the risk assessment to address the OM breakdown endpoint will be finding out how relevant the single-species soil fauna tests are to the litter mass loss endpoint.

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